Overview of VV&A Tools, Templates, and Resources

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Abstract

Verification, validation, and accreditation (VV&A) is a collection of processes that apply incremental reviews, analyses, evaluations, and tests to modeling and simulation (M&S) products for the purpose of establishing M&S credibility and reducing risk to the user. Under current Department of Defense (DoD) policy, all models and simulations used within the DoD must undergo VV&A. These processes provide many benefits to the M&S community including enhanced user confidence, improved system performance and reliability, and more predictable and accurate M&S behavior. When executed properly, VV&A enhances the many benefits of M&S including cost savings, risk reduction, and schedule acceleration.

By developing and applying tools, templates, and resources, the M&S community can reduce the time, effort, and cost associated with performing VV&A. The DoD M&S Master Plan notes the need to develop "standardized automated tools to support VV&A." These "tools" certainly include templates and resources. The SIMVAL99 conference report also emphasizes this need and states that "the VV&A community is not exploiting existing technology as much as desired." The software development community is already taking advantage of commercially produced tools, templates, and resources.

This paper provides an overview discussion for the Foundations '02 session on VV&A tools, templates, and resources. The paper presents the needs for these along with their definitions. Details will be left to the two main papers in this session. The goal of this paper is to "prime the pump" for audience discussions at the conclusion of this session.

1. Introduction

Modeling and simulation are assuming an ever-larger role in training, analysis, and acquisition for military and commercial systems because of their potential for cost savings, risk reduction, and schedule acceleration. Since models and simulations approximate the real world, their results also approximate, and hence we incur risks in M&S applications that depend on specific situations, environments, and circumstances. The fundamental goal of VV&A is to reduce this risk by improving the credibility of M&S results.

Many users perceive VV&A as taking too long, costing too much, and not being credible in itself. Further, acquisition program managers often view VV&A as yet another mandated drain

on their limited resources while complaining that there is no "tried and true approach" to applying VV&A and that there is no way to know "how much is enough." These perceptions must be balanced by the real need to guarantee that a program is (1) using correct models and simulations, and (2) using correct models and simulations correctly. The appropriate compromise is to perform effective VV&A more quickly and at less cost.

One method for reducing VV&A cost and schedule is to develop and apply tools, templates, and resources. The DoD M&S Master Plan [1], in sub-objective 5-2 (3), notes the need to develop "standardized automated tools to support VV&A." Moreover, as noted at the SIMVAL99 Conference [2] sponsored by the Military Operations Research Society:

> "It appears that the VV&A community is not exploiting existing technology as much as desired. The reasons for this are manifold. First, M&S management and VV&A practitioners *as a whole* are woefully unaware of existing tools and technologies that could be used to support VV&A. Second, the VV&A community has focused primarily to date on defining terminology and developing methodologies and processes, and has not given adequate attention to the potential benefits of tools and technologies. Other reasons include the lack of a comprehensive survey of tools and technologies available to support the education of the VV&A community or the use of these resources in DoD and elsewhere. No central repository exists to document VV&A tool use or to serve as a resource for future applications of VV&A tools and technologies."

There are a surprising number of tools that can be applied to the VV&A of models and simulations, and more such tools are under development. For example, the Software Engineering Institute's Capability Maturity Model (SEI CMM) [3] lists many techniques and approaches that have spurred the development of automated tools. The Modeling and Simulation Information Analysis Center (MSIAC) has published a two-part state of the art report [4,5] listing and categorizing automated support tools for VV&A. But as noted in the MSIAC report, there are not nearly enough tools yet, nor do the existing tools satisfy all of the community needs. Directly relevant to this Foundations '02 conference, although there are many *techniques* suitable for supporting M&S validation, there are not enough *tools* that implement these techniques. For example, there are not sufficient automated VV&A support tools that "instrument" M&S exercises analogous to test and evaluation tools that instrument live exercises.

If this is not a bleak enough picture, then consider that "the lot in life" for VV&A tools, templates, and resources is going to get harder since they will need to evolve together with the M&S trends towards the increased use of distributed simulations, high fidelity, and advanced "black box" modeling techniques. Namely,

- Distributed M&S systems require the development of automated VV&A tools that can act across simulation components. This is necessary since understanding the behavior of all the components in a distributed exercise individually is not sufficient for understanding the behavior of the system as a whole.

- High fidelity distributed simulations require the development of specialized "simulation instrumentation" tools to assure credibility in analysis, training, acquisition, and experimentation.

- Advanced modeling techniques such as neural networks and genetic programs require the development of automated VV&A tools that can be effective when applied to "black boxes" that normally inhibit understanding of their inner workings. The same situation applies to the use of COTS products, inherited objects with encapsulated mechanisms (in object-oriented systems), or components with differing security classifications.

2. Topic Overview

2.1 The Need for VV&A Tools, Templates, and Other Resources

VV&A tools, templates, and other resources can be used or appreciated by three different types of people who interact with simulations. These are the decision makers, the M&S users, and the M&S developers. All three types need to worry about making more credible decisions based on models and simulations. They also need to support quicker decisions at reduced cost. VV&A tools, templates, and resources are designed precisely to provide partial solutions to these problems since tools, templates, and resources reduce risk.

The advantages provided by tools, templates, and other resources in our current funding-limited and schedule-limited environment for M&S include:

- allowing us to do a better job,
- allowing us to do more in less time,
- allowing us to do our jobs at less expense,
- reducing risk in performing VV&A,
- allowing better cost estimating and planning,
- allowing better scheduling estimating and planning,
- eliminating "reinventing the wheel", and
- making our jobs easier.

These advantages are often linked. For example, reducing schedule usually leads to lowering cost!

Without applying tools, templates, and resources, the M&S community will find it difficult to respond to the criticisms noted above concerning effective approaches and costs of VV&A.

2.2 VV&A Tools

Tools are software/hardware programs, routines, algorithms, etc., that can be used and reused to automate and support parts of the VV&A process. Detailed discussions and analyses of VV&A tools will be provided in an accompanying paper titled "Automated Support Tools for Verification, Validation, and Accreditation."[6]

One way to categorize VV&A tools is as follows:

- *Documentation tools* that include planning and documentation aids, and software documentation tools.
- *Development environments* that include software development environments, modeling tools and simulation development environments, and federation development tools.
- *Supporting tools* that include visualization tools, and mathematics and statistics packages.
- *Verification tools* that include requirements management, specification, and tracing tools; automated testing/measurement/debugging tools; simulation testing tools; and coding standards enforcement tools.
- *Configuration management tools* that monitor, track, and control changes to software.
- *Software costing tools* that estimate the development costs of software systems, including verification and validation systems.
- *Other tools* that include compilation tools, reliability evaluation tools, database checker and design tools, optimizers for simulation inputs, floating point error analysis tools, software analysis tools, and error collection and analysis tools.

There are many tools that can be used for the V&V of models and simulations. Many of these originate in the software industry. However, there are differences between software in general and M&S in particular that must be noted when applying these tools. One is that M&S is designed to emulate real world system behavior while software is designed to perform functions that are usually not emulations. Another difference is that simulations may need to operate in modes that are not pre-specified so that emerging behavior or responses in unknown regimes can be investigated. Further, M&S includes the conceptual model, an extra layer of requirements, assumptions, approaches, and algorithms. These differences must be kept in mind when adopting or adapting tools from the software industry.

What should be known about individual VV&A tools before they are applied? Basic information should include:

- their name,
- their basic application (verification, validation, and/or accreditation),
- the simulation phases, environments, or aspects they cover,
- their owner (sponsor),
- their developer,
- their maintainer,
- their users,
- their use history,
- their training provider,
- their cost,
- their provider,
- their proprietary status,
- their use considerations: host computer, disk space/RAM, operating system, source code language, etc.

This is the sort of information collected for the tools in the MSIAC state of the art report [5]. The companion paper on tools covers these considerations in more detail.

2.3 VV&A Templates

Templates are written/automated standardized formats/cookbooks that can be used to organize, record, and present material relevant to the VV&A process. Detailed discussions and analyses of VV&A templates will be provided in the accompanying paper titled "Templates and Resources for Verification, Validation, and Accreditation."[7]

Examples of different types of VV&A templates include:

- verification plan templates
- verification report templates
- validation plan templates
- validation report templates
- credibility templates
- data quality templates
- accreditation plan templates
- accreditation package templates
- accreditation report templates
- accreditation decision letter templates

These templates provide standardized formats for documenting plans, reports, and letters; detailed guidance on developing plans, detailed guidance on gathering and organizing the necessary documentation, detailed guidance on developing reports, guidance on making the accreditation decision, and/or outline structures for formatting accreditation plan contents.

What should be known about VV&A templates before they are applied? Mostly the same information noted above for VV&A tools applies here, namely:

- their name,
- their basic application (verification, validation, and/or accreditation),
- their owner (sponsor),
- their developer,
- their maintainer,
- their users,
- their use history,
- their training provider,
- their cost,
- their provider,
- their proprietary status.

2.4 VV&A Resources

Resources are repositories, websites, reflectors, organizations, conferences, conference proceedings, papers/reports, bibliographies, and subject matter experts that contain (or are knowledgeable concerning) references, toolsets, policies, and information documenting approaches to and experience in performing the VV&A process. Detailed discussions and

analyses of VV&A resources will be provided in the accompanying paper titled "Templates and Resources for Verification, Validation, and Accreditation."[7].

Categories of resources include:

- repositories – such as the DMSO Modeling and Simulation Resource Repository (MSRR), the individual service MSRRs, and the MDA MSRR.
- websites – such as the DMSO VV&A Recommended Practices Guide (RPG) website [8]
- reflectors – such as the SISO VV&A Forum Reflector
- organizations – such as the DMSO VV&A RPG Team, JASA, NAVMSMO, AMSO, AFAMS, and the MSIAC.
- conferences – such as SIMVAL99, the JASA-sponsored Reno conferences ("Assuring M&S Credibility for Defense Acquisition and T&E Survivability, Lethality, and System Effectiveness", ...), the Simulation Interoperability Workshops VV&A Forum, Summer Computer Simulation Conference, and the Advanced Simulation Technology Conference tracks.
- conference proceedings – such as provided in hardcopy and/or CD-ROM by the above conferences
- papers/reports – such as the Navy VV&A Implementation Handbook [9] and the references in this paper and others at Foundations '02
- bibliographies – such as provided in the preliminary material for Foundations '02
- subject matter experts – such as the attendees at this conference.

The MSIAC report [5] also contains detailed information concerning selected VV&A resources.

2.5 Tools, Templates and Other Resources: Discovery and Repositories

How do the decision makers and the members of the modeling and simulation community find out about VV&A tools, templates, and other resources? Understanding and improving this process is vital to the successful applications of these tools. If the users don't know about them, they can't use them.

Clearly, some possible methods of discovery include:

- attending this conference,
- asking colleagues and friends,
- reviewing the literature (SIW, SCSC),
- obtaining the MSIAC state of the art reports,
- surfing the web, or
- querying a repository.

The VV&A practitioners must enhance these existing information delivery channels and most likely augment them with additional methods as the problem is more fully understood.

The SIMVAL99 conference noted the need for a repository of VV&A tools, templates, and other resources. There are many issues associated with the creation and maintenance of such a repository. Certainly, these issues include:

- who hosts it?
- who populates it?
- who pays to populate it?
- who maintains it?
- who has access to it?
- who develops the taxonomy for it?
- what exactly does it contain (metadata and/or actual tools)?
- what is its relationship to the MSRR and/or other repositories?

One recurring issue with repositories is the willingness of the "owners" of the tools to share them. The tradeoff gains of sharing must be understood and explained and then balanced with the corresponding tradeoff losses.

2.6 Other Issues

This section assembles some related issues associated with VV&A tools, templates, and other resources.

- Should VV&A tools, templates, and other resources follow standards? What are the advantages and disadvantages? Who would set the standards? Who would enforce the standards? Who would pay to operate the standards group?

- Should there be a central planning function for VV&A tools, templates, and other resources (including processes for identifying gaps in tools, etc)? Who would evaluate the gaps? Who would decide how these gaps would be filled and by whom? Who would pay to operate the planning function?

3. Conclusions

Our general conclusion is that the use of VV&A tools, templates, and other resources should be expanded to:

- expedite the VV&A process,
- increase confidence in the outcome of the VV&A process, and
- reduce cost and/or cost uncertainty of the VV&A process.

The ultimate goal, of course, is to reduce the risk in using models and simulations, provide more credible models and simulations, and support better decisions.

More specific conclusions include:

- The M&S community should develop new automated testing tools to support effective VV&A. There is a special need for tools supporting the verification and validation of distributed simulations and even more so for high fidelity distributed simulations. These tools should be analogs of the automated testing tools used in the testing and evaluation community, and analyze all the details of model interactions during exercise runtime.

- The M&S community should adopt or adapt tools and templates from the software industry to support verification and validation as possible. The software industry provides many tools and templates already used in VV&A efforts. Software tool providers are well supported in their industry and are developing new tools and templates based on current technologies as well as entirely new approaches to verifying and validating software code. These developments should be monitored for potential applications to M&S.

- The M&S community should make more and better use of visualization tools in support of VV&A. Visualization tools help M&S developers and users to determine if a system "looks right" and if it is representing reality correctly. These tools support understanding of data, results, and system dynamics. Tools such as CAD/CAM viewers, 3D walkthroughs, exercise stealth viewers, and graphing packages for statistical analysis are all directly applicable to VV&A.

- The M&S community needs a central repository to store and disseminate information about VV&A tools, templates, and other resources. The repository should be accessible to all practitioners of VV&A.

- The M&S community should develop new processes and types of tools that permit feedback of system information. The M&S community needs to enhance the use of models and simulations in support of the entire system development lifecycle through the concept of simulation based acquisition. This will require developing new processes and new tools that permit feeding actual results from system testing and deployment back into the core suite of M&S.

- The M&S community should develop new approaches and automated tools that increase the credibility of simulations by providing a quantitative measure of assurance that the results of a simulation exercise are within a given accuracy over a specified range of inputs.

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6. Authors' Biographies

Dr. Jerry M. Feinberg has over twenty five years of experience in managing and conducting studies and analyses of military systems and in strategic science and technology planning. He is a co-author of the two-part MSIAC state of the art report titled "Automated Support Tools for VV&A." He is the Chief Scientist and Knowledge Manager for the Modeling and Simulation Information Analysis Center (MSIAC). His expertise is in technology planning; distributed modeling and simulation; simulation based acquisition (SBA); verification, validation, and accreditation (VV&A); analysis of alternatives, and intelligent agent technology. He has been awarded two patents in the applications of intelligent agents to models and simulations and to distributed information technology systems.

Dr. Patrick W. Goalwin has fifteen years of experience in DoD-related physics-based modeling and simulation. He is a co-author of the two-part MSIAC state of the art report titled "Automated Support Tools for VV&A." He has developed, used and modified distributed interactive

simulations of sonar systems, and has developed, used, and modified simulations of radars for remote sensing and missile defense, and passive microwave radiometers for remote sensing. He has participated in four separate technology reviews. At the MSIAC, Dr. Goalwin has been involved with state of the art report production and the analysis of technology for Human and Organizational Behavior Modeling.